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A new method for investigating the movement patterns of children has been developed. It uses a computer analysis and display procedure for reducing Cartesian coordinate position data to numerical and graphical statements about movement patterns. A time-lapse photographic system is used to obtain the position data for children during play. This study explored (1) the potentialities and limitations of this new method and (2) the difference in movement patterns of preschool children with succeeding play sessions. Four groups of preschool children were filmed while engaging in a 15-minute play session during nursery school. Each group was filmed for nine sessions. The playroom was arranged the same way for the first six sessions. On the seventh, a novel apparatus was introduced. The data analysis indicated that as a group the children showed less movement over succeeding sessions. The introduction of the novel object was accompanied by a substantial decrease in movement, with play gravitating to that object. Teacher presence was found to influence movement also. The findings of this study, coupled with suggested revisions of the method, indicate that the technique can be used successfully to collect and analyze children's movement patterns in a closed environment. (WD)

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A METHOD TO INVESTIGATE THE MOVEMENT PATTERNS OF CHILDREN[1]

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Most of the research on the movement patterns of children has involved drawing the path of a subject on a diagram as he moves about the experimental area and taking written note of the activities in which he engages. Barker (1930), in studying the social-material activities of young children, used observers to chart on a scaled floor plan the movements of a child during five-minute intervals. Individual differences were revealed by tabulating gross distance covered, number of activities engaged in, the distribution of time among the activities, average number of activities per unit of time, and the number of social contacts.

Dow (1933) charted subject movement in a study of the reactions of children to the presence or absence of playground equipment. Scaled plans of four different playgound areas were prepared by a surveyor. The observer, stationed so that all four areas were in view, traced on the proper chart the

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movement of a subject from point to point for one-minute intervals. A running descriptive account of all activities engaged in by the subject was made at the same time by the same observer.

Hutt, Hutt, and Ounsted (1963) tape-recorded descriptions of children's changes in position with reference to permanent tile squares on a playroom floor. Each child's movements were then plotted on a numbered representation of the floor space by drawing arrows between the appropriate squares. In addition a description of the child's activity was also transcribed from the tape-recorded descriptions.

Swinton (1934) recorded the movement of several subjects simultaneously by means of time-lapse photography. A camera was mounted on the roof of a building overlooking a playground area. The activity of a group of five-year old children was filmed for a total of one hour using two-second intervals between pictures. Pictures of the playground site were used to trace the movement paths of the children, one minute of film being recorded on one picture. Variables included the interest value of the equipment, the amount and character of physical activity, and social behavior.

A unique device was used by Ellis and Pryer (1959) to study the gross bodily activity (distance moved) of children with pronounced neuropathology. An eight-foot by eight-foot activity room was criss-crossed at two-foot intervals with beams of light which were focused on photoelectric cells on the opposite side of the room. A child's movement broke a light beam and an impulse was registered on a counter. An observer recorded the score on each of six counters at five-minute intervals.

While various procedures have been used, improved methods for the investigation of movement patterns of children need to be developed to alleviate some of the problems that have plagued researchers in the past. The problems most critical for additional methodological consideration seem to be: 1) minimization of observer influence; 2) achievement of greater objectivity; 3) simplification and systematization of the data collection and analysis procedures; 4) minimization of time and cost factors; and 5) maximization of versitility and ease of application.

In an attempt to overcome some of these problems Herron and Frobish (in press) (HF) developed a computer analysis and display procedure for reducing Cartesian coordinate position data to numerical and graphical statements about movement patterns. A time-lapse photographic system was to be used to obtain the position data for pre-school children during play. Each child's coordinates were identified in each picture by means of a grid taped onto the floor of a playroon. However, the method was not substantially tested by HF. The reliability and validity of the method remained in question, and substantial application in the field was crucially needed. The present study was concerned with 1) exploring the potentialities and limitations of the method of data collection and computer analysis designed by HF, and 2) exploring the question, "How do the movement patterns of three and four year old children differ with succeeding play sessions?"

Method

To accomplish the above purposes the HF method was tested over a four-week period by the Motor Performance Laboratory staff using normal children

attending the nursery school at the Children's Research Center, University of Illinois.[4] The composition of these four groups remained unchanged during the four-week period of data collection.

Use of the playroom by the children was scheduled so that the two morning groups alternated days as did the two afternoon groups. Since the nursery school operated on a five-day basis, a particular group used the playroom three times one week and two times the next week.

A remotely-controlled 35 mm camera with a fisheye lens was semi-permanently mounted on the ceiling of an indoor playroom. With this arrangement the whole play area could be photographed on a single exposure. Pictures were taken automatically at regular ten-second intervals by means of a specially-built "intervalometer."

Each play session lasted for fifteen minutes and thus ninety pictures or exposures per session were obtained. A grid of one-yard squares was taped to the floor of the playroom so that the position of each child in each exposure could be recorded in terms of Cartesian coordinates. This method was deemed superior to placing a transparent grid over the photographs.

The camera was visible to the children throughout the filming period and the sound of the motor-drive could be heard during each exposure. This distraction provoked some interest and curiosity in the children, especially

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[4]The time-lapse photographic system was developed by a research team at the Motor Performance Laboratory which involved Mike J. Ellis, Robert J. Korb, Lance H. Wuellner, and Robin E. Herron.

during the first few sessions for each group. However, as a result of viewing both the photographs and a limited amount of video-tape of the play sessions, it was felt that the data was not significantly contaminated to render it useless.

Lee and Hutt (1964) designed a playroom for filming children in which the camera could not be seen. The camera was placed inside a specially-constructed filming cubicle adjacent to the room. However, the filming was not done in such a way as to obtain position data by the present study.

The approximate center of gravity of each child was used as a basis for plotting his position. All coordinate points were recorded using .2 yard intervals. This proceudre and the punching of data on IBM cards were the only manual steps involved in the study.

Haith (1966) has described a semi-automatic method for reading position data after it has been recorded on film. A wire grid stood in front of a screen onto which the film had been projected. A scorer touched a metal probe to the vertical and horizontal wires nearest the points on the projected image he wished to measure and the coordinates of the points were automatically punched on IBM cards. In the present study, due to the picture distortion caused by the fisheye lens, adaptation of Haith's method appeared to be both difficult and expensive.

In the present study each of the four groups of children was filmed a total of nine times. After the first six sessions a "novel" apparatus was introduced, the original arrangement being kept the same except for a slight adjustment to accommodate the new piece of equipment. One of the afternoon

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groups was also video-taped during its first four sessions. This was done with the intention of estimating the extent to which exposures taken at ten-second intervals faithfully reflected the children's activity over the course of a fifteen-minute play session.

Future video-taping will be done to validate the relationships between the movement patterns derived by the described technique and social-psychological indices of social interaction. Further study will also be conducted on the length of the interval between pictures. Analysis of pictures taken at 2, 4, 8, and 16 seconds will enable finding the optimal interval of both efficiency and validity of description.

Results

The analysis of the data is divided into two sections: 1) reliability of the data collection method, and 2) preliminary studies and projected future studies pertaining to movement patterns of children's play.

Both inter- and intra-observer reliability was calculated for the procedure of transcribing the Cartesian coordinates from the photographs to the IBM cards. Conservatively stated both of these procedures yielded reliability in excess of .98, with 98% of the errors being .2 yards in magnitude or less.

It was noted that 64.1% more errors were made in recording the X coordinate than in recording the Y coordinate. This finding seemed to suggest that in using a fisheye lens there are practical limitations on the size of room that can be photographed and the minimum size of picture that can be used in the analysis procedure.

Based on an inspection of the initial computer output supplied by the HF program, the computer analysis and display procedures were altered to more

adequately provide data necessary for statistical manipulations.[5] The present computer output consists of the following:

1) The average distance of each child from all of the other children in his group. This data is supplied for each picture, each session, and for all nine sessions as a whole. The range and variance of these figures are also printed.

2) The average distance moved by each child during each play session and for the nine sessions taken as a whole. Distance moved is calculated by summing the change-in-position vectors between successive pictures The range and variance for these movement measures are also supplied.

3) The play areas occupied by each child at the end of each ten second interval. Areas are represented as decimals with apparatus numbers to the left of the decimal point and quadrant of the room to the right of the decimal point.

4) The frequency of entry per session of each child into each of the specified play areas. In addition totals for all children per area are computed per session and for all sessions as a whole.

5) The frequency per session that a given child is alone in each of the specified play areas. Frequencies for all children per area are computed per session and for all esssions as a whole.

6) Graphic interpretations of each of the previous five categories of data. Although at present the graphic section of the computer analysis is incomplete it is hoped that further analysis of the data will yield information as to which data items can be appropriately displayed. Computer output of graphical displays such as movement patterns involves much time and expense, and while esthetically pleasing, their usefulness in questionable.

Even with the program changes data is still difficult to analyze due to several uncontrolled interacting variables. The presence of a teacher in the play area seemed to effect the type of play behavior of the children. In addition, children were removed at certain times from the playroom for use in other experiments conducted at the Research Center. Finally, the camera failed on two occasions rendering noncomparable the effective shooting schedule for two of the groups with that of the other two. However, several conclusions seemed tenable despite the shortcomings in procedure and method.

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In order to analyze some of the differences in movement patterns between groups and individuals with groups, a Teacher x Age x Sessions (2x2x9) analysis of variance was conducted using the distance moved per picture per child average over an entire session as the scores.

Insert Table 1 about here

A significant Sessions factor indicated that average distance moved averaging over teachers and ages tended to decrease over the nine sessions. A significant ($F=131.00$, $df=1/192$, $p<.01$) negative linear component of this trend was noted

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Insert Figure I about here

(Edwards, 1968). This indicated that as a group the children showed less movement over succeeding sessions.

After the novel object was introduced in session seven, movement seemed to fall off drastically and only showed slight fluctuations over the next two sessions. The data pertaining to frequency of entrance into play areas showed that when the novel object was introduced children spent most of their time playing in, on, or around it; and only in session 9 did they begin to more evenly distribute their attention to all play areas in the room.

The Age factor of the analysis of variance indicated that the three year olds showed less movement between pictures than the four year olds averaging over sessions and teachers. However, as can be seen from figure two, it is not so much the absolute difference in movement but rather the difference in trends that is of interest ($F=108.3$, $df=1/192$, $p<.01$). The four year olds show a significant

Insert Figure 2 about here

highly negative linear trend over the 9 sessions while the three year olds show a more constant yet still negative trend.

Again when the novel object is introduced the four year olds show a drastic drop in activity level and after slight fluctation continue their overall negative trend. The three year olds show a slight general increase in movement after the novel object is introduced although not enough to make the overall trend positive.

The Teacher factor indicated that while a difference in distance moved existed between the two groups taught by teacher one and the groups taught by teacher two, this difference was not significant. However, the significant Teacher Age and significant Teacher x Age x Sessions interactions indicated that the teachers had opposite effects for the two age groups and additional interactive effects over the nine sessions. This indicates that the teachers were in some way influencing the movement of their students but that one teacher had a greater effect on three year olds and the other on four year olds.

Insert Figure III about here

A Sex x Sessions (2x9) analysis of variance using the same movement scores as the previous analysis revealed that males showed significantly ($F=4.98$, $df=1/26$, $p<.05$) more movement than females averaging over sessions. However, the Sex x Sessions interaction was not significant ($F=1.07$, $df=8/208$, $p<.05$) indicati

that the trend for the two sex groups over sessions was not significantly different.

A summary look at the other categories of data yielded the following additional information about the movement patterns of the two age groups:

1) A comparison of the amount of time spent on equipment versus the time spent in open areas in the room was somewhat similar for the two age groups although the three year olds showed greater within group variability than the four year olds. Further, it seemed that the more time children spent in open areas the more movement they showed. This finding can either be interpreted to mean that the children used the open areas for play purposes involving the fantasizing cowboys-and-indians-type games or that they simply used the open areas to cross from one piece of equipment to another. An analysis of the length of behavior sequences in the open areas revealed that 75% of the instances when children went into the open areas were less than 10 seconds in length. This would suggest that, by and large, the open areas were used for movement between objects purposes.

2) The two age groups differ in amount of time they spend alone in the equipment areas. The four year olds average 22.5% of their time alone on equipment while the three year olds average 15.2%. In addition, the four year olds tend to show a wider variety of play group sizes while the three year olds spend more their time in groups of three or more.

In total the data presented can be used to both develop hypotheses concerning the play patterns of nursery school children and to help validate already exsisting theories.

The following list of studies are included to further show the versatility of the data and possible directions that future studies at the Motor Performance

Laboratory might take:

1) A Child X Play Area X Number of Children in a Play Area X Sessions table can be formed to delineate the differences in area usage by the various children, how many children play in a given area, and what areas receive maximum and minimum attention. In addition,conditional probabilities can be calculated showing the probability of using each piece of equipment having been on another apparatus. Along with a quality rating of the functions and uses of each play area this analysis could give possible evidence for constructing a theory of play behavior.

2) An average distance between each child and each other child matrix can be formed and factored to yield information as to play groupings. This data could be compared to standard sociometric data reflecting cliques or friendship groups during play periods.

3) Variables such as sex, I.Q., ordinal position, socio-economic status and other relevant background data could be used to explain differences between individual and group play patterns.

4) The role of the teacher could be more adequately controlled to bring into clearer focus the effect of adult presense and response on children's play behavior.

5) The concept of territoriality could be investigated, analyzing the frequencies each child is alone in each area and the responses of other children to another child's occupation of an area.

While incomplete, this list of studies notes the variety of areas that the present data can be used to investigate. It is hoped that greater insight will yield even more relationships and data manipulation from the basic computer output.

Discussion and Conclusion

Based on the above preliminary findings and projected plans for future studies the authors feel that the original HF data collection technique can be used with the aforementioned revisions to successfully collect and analyze data concerning the movement patterns of children during play. The authors can also see the utility of the technique for studying movement patterns in

general in any kind of closed environment. Studies of hyperactivity and behavior in response in stimulant or depressant drugs appear to be meaningful areas for application of the technique. In addition the play or work environment could be studied in terms of visual, tactual, personal, and other related stimuli. The system also shows promise for looking at social interaction involving adult groups where the major variables of interest can be defined in terms of distance travelled or distance between individuals.

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TABLE 1

ANALYSIS OF VARIANCE FOR AVERAGE DISTANCE MOVED PER SESSION

Source	df	MS	F
Teacher (A)	1	0.90	2.57
Age (B)	1	6.30	18.12**
AxB	1	2.14	6.11*
Ss (within treament)	24	0.35	
Sessions (C)	8	1.02	34.00**
AxC	8	0.23	8.21**
BxC	8	0.45	15.00**
AxBxC	8	0.47	15.67**
CxSs	192	0.03	

*p< .05

**p< .01

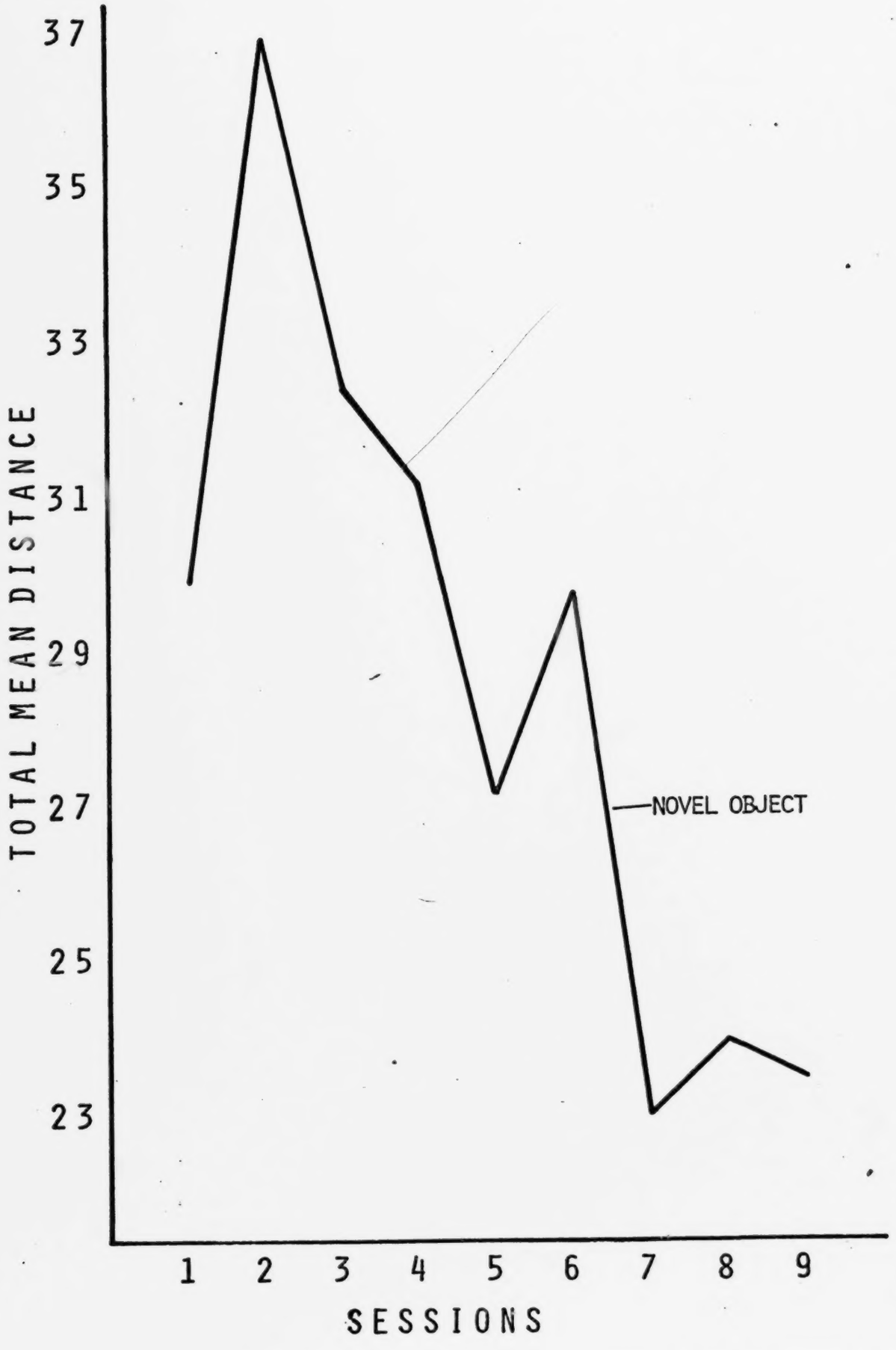

FIGURE 1

MEAN DISTANCE FOR ALL GROUPS

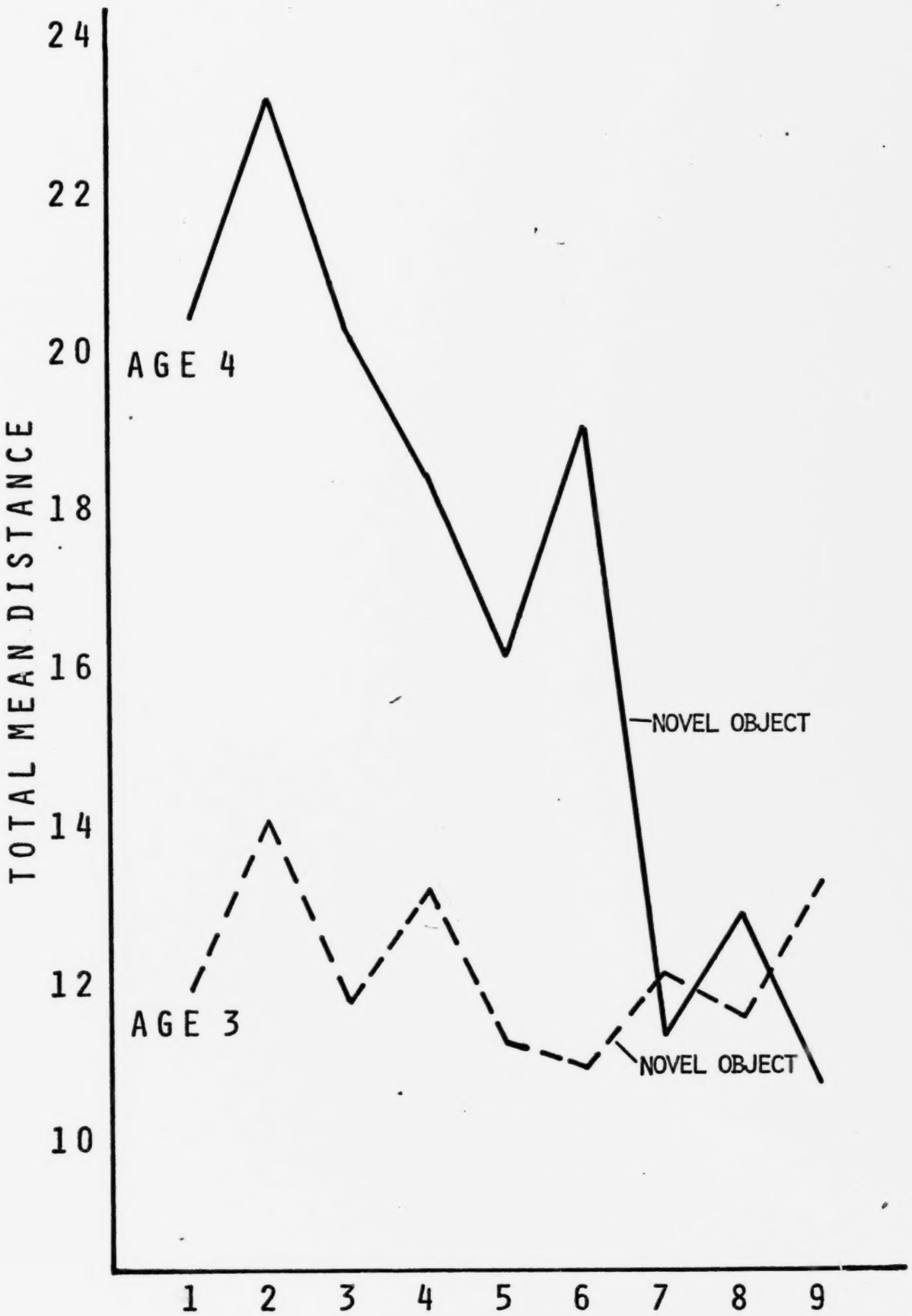

FIGURE 2

MEAN DISTANCE BETWEEN AGE GROUPS

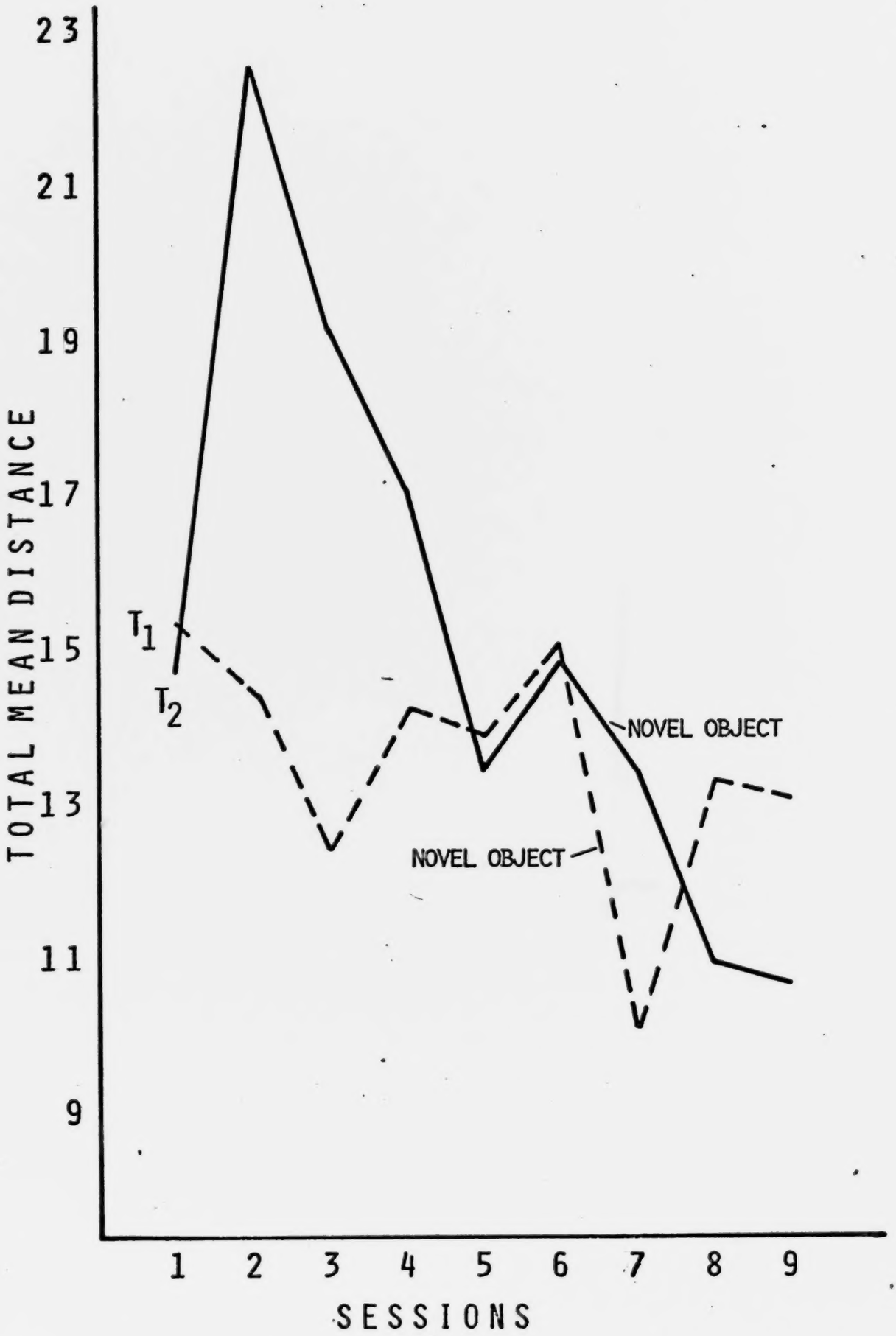

FIGURE 3

MEAN DISTANCE BETWEEN TEACHER GROUPS